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INCREASED MJF BUILD EFFICIENCY THAT ENABLE NON-PRINTED PART-IN-SITU BUILDS THRU MULTIDIMENSIONAL BUILD LAYOUT(S)

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Increased MJF build efficiency that enable non-printed part in-situ builds thru multidimensional build layout(s)

This disclosure describes a generalized approach to introduce non 3D printed elements, (components or specialized agents), into a 3D printed part while avoiding the otherwise typical, (and negative) impact on build efficiency that can occur due to pauses in the 3D fusion process required for introduction of said elements. This effectively enables in-situ fabrication/integration of same.

A typical 3D print fabricated part is created through sequential exposures of planar "slices" of a given part that by virtue of fusing to the prior layer, sequentially fabricate a part layer by layer until completion of said part. As such, the number of parts fabricated per a given build job is typically limited by the packing density per a given layer in the build plane, typically referred to as the X-Y plane.

Additionally, job build efficiency is negatively impacted if there is a need for introducing specialized agents and/or non 3D printed components into the construction of an otherwise typical 3D print fabricated part. The act of introducing a non-printed component requires a pause in the otherwise continuous build process to permit the placement of such a component in the proper X-Y location on the part mid-fabrication. The longer this pause, the more the negative impact on the otherwise finely tuned processing parameters that ensure a quality 3D printed part with structural integrity typically achieved thru proper bonding between fabrication layers used to build said part. This disclosure improves on build efficiency by exploiting all three dimensions, X, Y, and Z thus mitigating the impact of the build process pause required to introduce a non-printed component into an otherwise continuous print job.

Prior solutions to mitigate the impact of any process pause required by introduction of a non-printed component into a print job have typically focused on reduction of an allotted processing pause for introduction of the component thru either faster tooling motions or multiple in parallel component operations for a given pause or the combination of both. The speed of the tooling becomes the limiting factor for single up operations and the multiple parallel placement approaches suffer from added tool complexity and are typically dependent on part type and location in each X-Y build plane making reconfiguration between different parts extremely difficult in terms of hardware and job flexibility.

This disclosure describes a methodology enabling a non-3 D printed part or specialized agent is to be introduced in mid build while largely mitigating the said challenges. This is accomplished in the following fashion:

1) Determine the maximum allowed pause in the build fusing process that is permitted without compromising final part structural integrity.
2) Determine the number of specialized operations that can be accomplished in the allotted time as dictated by Step #1 above.
3) On a common X-Y build plane, layout the part X-Y locations as if the entire plane was being optimized in the X-Y plane.
4) Create subgroups of parts within the overall X-Y plane, the quantity within said group to not exceed the number of parts determined in Step #2 above.
5) Determine the number of build layers required to stabilize the build fusing process for a pause in the build sequence.

6) Take the subgroups of Step #4 above and progressively stagger them in the Z direction with an offset distance equal to the number of layers determined in Step #5 above multiplied by the build layer thickness. This offset will typically be fractions of the overall part height in the Z dimension.
7) Take this overall group of parts, laid out in a Z staggered collection of subgroups, and replicate it thru the rest of the 3D printer Z axis build volume maintaining the required Z offset, (as dictated in step #6 above) between overall part groups.
8) If appropriate, create an interlayer of parts as described in figure #2 below in a similar fashion and propagate it thru the 3D printer Z axis build volume to ensure a maximized number of build parts per 3-D printer build volume available.

For a multipart build on a 3D printer, the more typical approach of an optimized layout in an XY plane is shown in figure 1 below:

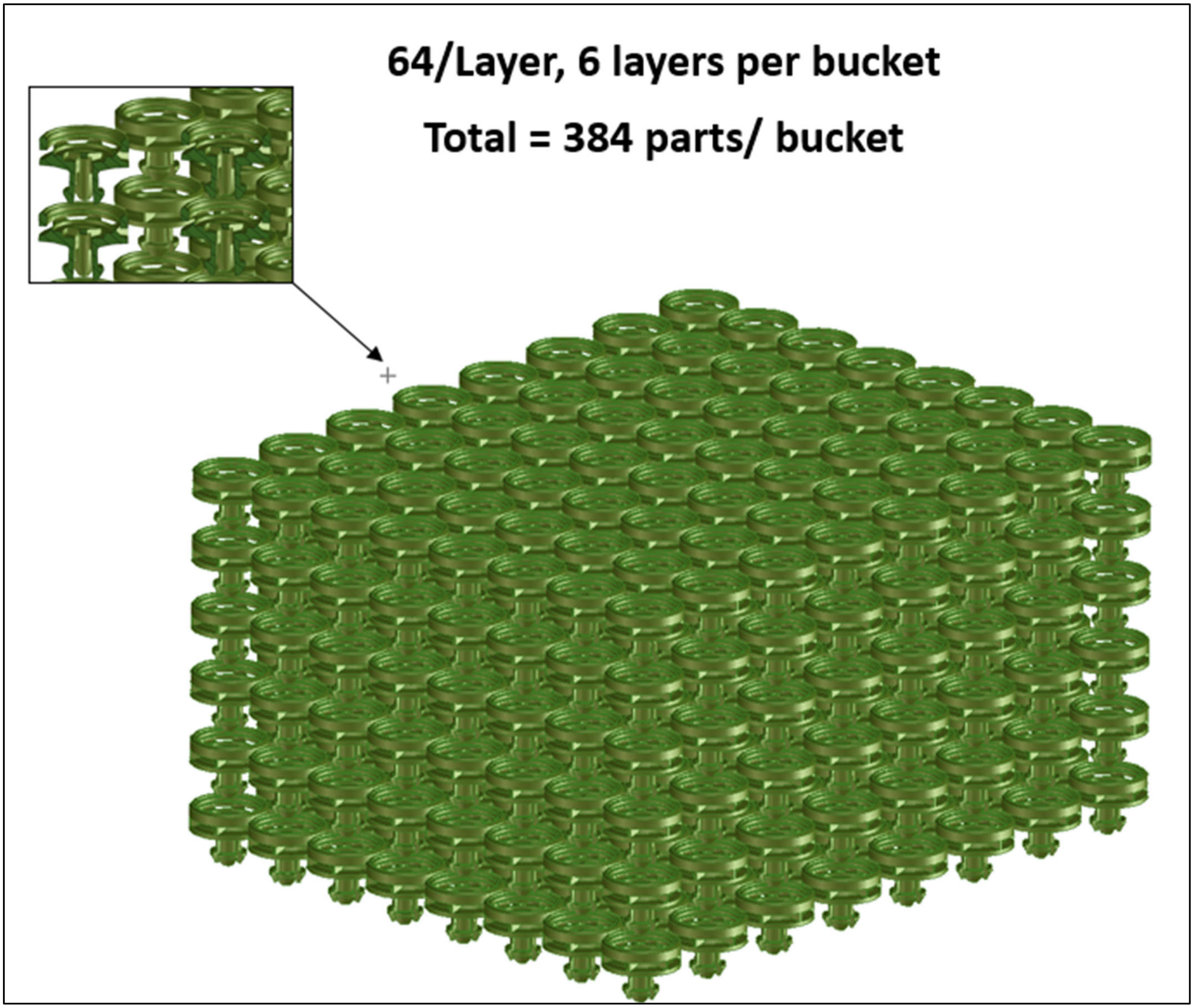

Figure 1: Bucket part count based on X-Y plane optimized layout

The method of this disclosure is to utilize a sub optimized X-Y planar layout that can be interdigitated between the existing otherwise optimized X-Y plane layouts to optimize the build quantity across the entire build volume available for a given 3D print job. One example of such an approach is shown in Figure 2 below:

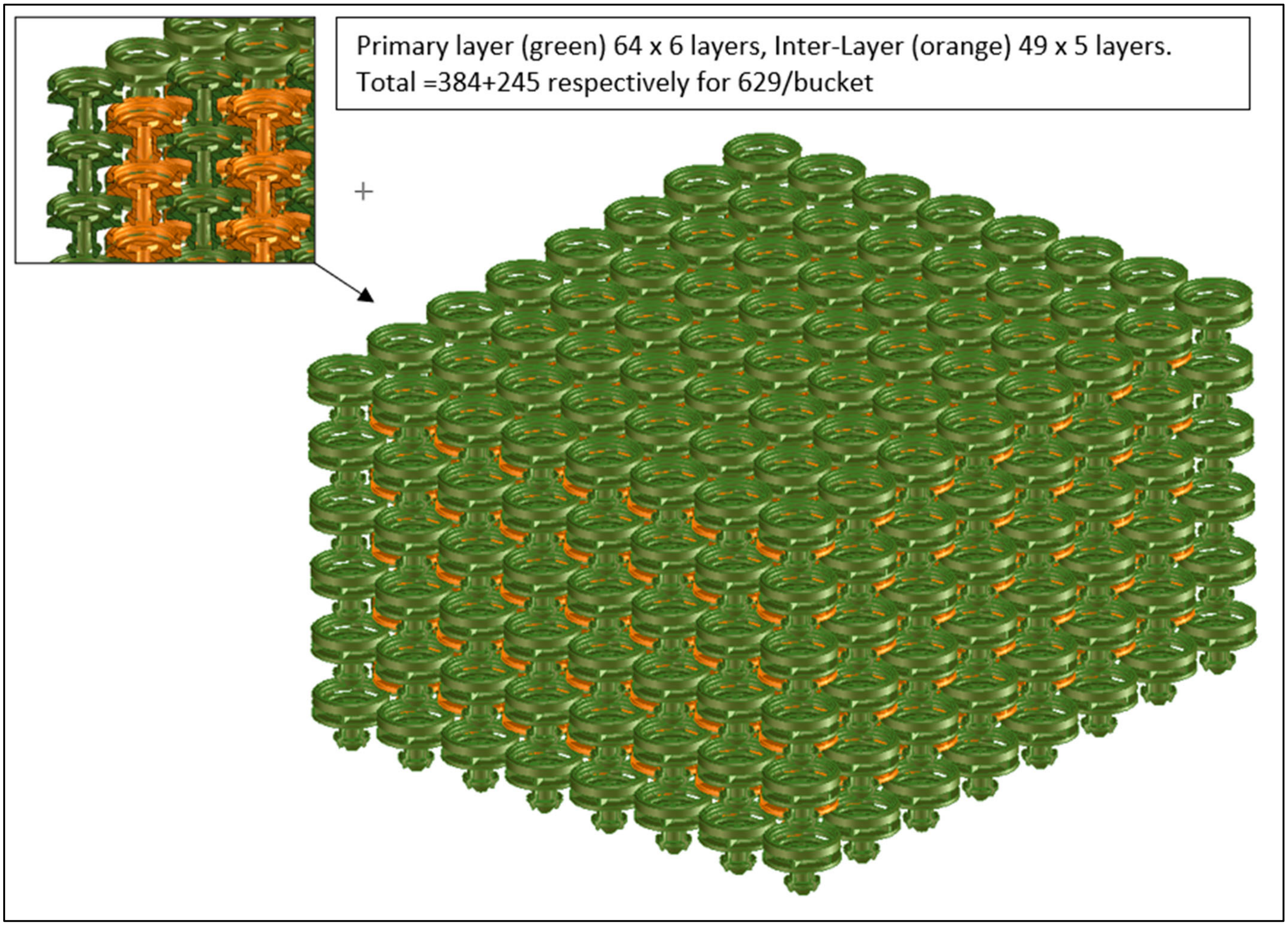

Figure 2: Build quantity optimized across all three dimensions X-Y-Z

For the part geometry shown, the resulting increase was 64% additional parts per a given build. Different part designs will dictate different levels of improvements in packing density with the degree of improvement largely dictated by variations in the X-Y plane footprint of the part as a function of the location in the Z axis on said part. Higher variation will tend to enable more improvement whereas no variation will exclude any improvement.

By using an offset in the Z axis between subsequent sub-groups that require the introduction of non-printed components or specialized agents, the above part layering method maximizes build efficiency for a given build volume while mitigating the impact of any pause in build processing required for introduction of said non-printed components or special agents. Typically, this offset will be a small fraction of the overall part dimension in Z, in general on the order of hundreds of microns.

General Advantages

1) Enables the introduction of non-printed components or specialized agents into a print job by mitigating negative impacts on part quality due to the inherent pause required to place such components during build processing.
2) Enables the cost efficient in-situ building of 3D printed components that integrate therein non-printed components or the use of additional agents. Such non-agent components would otherwise need to be introduced and mounted in post fabrication operations. The elimination of post fabrication assembly operations and components subsequently reduces the part cost of the completed assembly as a function of the simplification such an approach enables.
3)

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